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(54) **METHOD AND DEVICE FOR VIBRATION CONTROL**

METHODE UND VORRICHTUNG ZUR SCHWINGUNGSKONTROLLE

PROCEDE ET DISPOSITIF DE COMMANDE DE VIBRATION

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Description

Field of the Invention

[0001] The present invention relates to a method and a device for vibration control, and more specifically a device, a method and a tool holder for vibration control in cutting, according to the preambles of claims 1, 7 and 9 repectively.

Background Art

[0002] In cutting, such as turning, drilling, milling or planing, dynamic motion arises between the tool and the workpiece. The motion is largely due to the fact that the chip-forming process, i.e. the removal of the generally relatively hard material from the workpiece, results in dynamic excitation of the tool, especially the tool holder. The dynamic excitation results in a dynamic motion, in the form of, for instance, elastic bending or torsion, of the tool and the tool holder. The chip-forming process is largely stochastic and the excitation appears in the form of tool vibrations and noise. In addition to thus causing problems in the working environment, the dynamic motion also affects the evenness of the surface of the workpiece and the service life of the tool.

[0003] It is therefore important to reduce the dynamic motion as far as possible. It is known that the vibration problem is closely connected with the dynamic stiffness in the construction of the machine and the material of the workpiece. It has therefore been possible to reduce the problem to some extent by designing the construction of the machine in a manner that increases the dynamic stiffness.

[0004] An important part of the construction is the actual tool holder. The cutting tool, for instance turning insert (or tooth), milling teeth or drilling teeth, is rigidly supported by the tool holder. Consequently the vibrations arising between the cutting edge and the workpiece are transferred almost completely to the tool holder. In many cases, it is the lack of dynamic stiffness of the tool holder that is a main problem.

[0005] Efforts have therefore recently been made to increase the dynamic stiffness of the actual tool holder by means of active technique in order to control the response of the tool. This means that active control of the tool vibrations is applied.

[0006] The active control comprises the introduction of secondary vibrations, or countervibrations, in the tool by means of a secondary source which is often called actuator. The actuator is operated in such manner that the countervibrations interfere destructively with the tool vibrations.

[0007] US-4,409,659 discloses an example of such a control unit. An ultrasonic actuator is arranged on the tool holder and produces countervibrations in the tool. The operating current of the actuator is controlled according to physical parameters that are measured and by means of the work of the actuator are kept within defined limits. This construction is unwieldy since the actuator is a comparatively large component which must be mounted on a suitable surface of the tool holder. Moreover, the directive efficiency is not quite distinct.

[0008] JP-63,180,401, which is considered to represent the closest state of art, according to the preambles of claims 1, 7 and 9, discloses a very different solution where the actuator is built into the tool holder which holds a turning insert. A laterally extending through hole which is rectangular in cross-section is formed in the tool holder. A piezoelectric actuator, in series with a load detector, is fixed between the walls that define the hole in the longitudinal direction of the tool holder. The load detector detects the vibrations and is used by a control unit to generate, via the actuator, countervibrations which reduce the dynamic motion. This construction necessitates a considerable modification of the tool holder and indicates at the same time that the designer has not been aware of the essence of the excitation process. In fact, the modification counteracts the purpose of the construction by reducing the stiffness of the tool holder in the most important directions, above all vertically, which in itself causes a greater vibration problem, or alternatively means that the dimensions of the tool holder must be increased significantly in order to maintain the stiffness. During turning, the rotating workpiece produces a downwardly directed force on the cutting edge. When the cutting edge offers resistance, material is broken away from the workpiece. In this context, most of the vibrations arise. In JP-63,180,401, one imagines that the surface of the workpiece is uneven (wave-like) and thus mainly excites the tool holder in its longitudinal direction. Via the actuator, one generates an oscillation in opposition towards the wave pattern and thus obtains a constant cutting depth.

[0009] There is thus a need for a solution which controls the most essential vibrations in cutting, such as turning, milling, drilling or planing, and which causes a minimum of negative effects, such as bulky projections of dynamically weakening modifications, and still has a good effect.

Summary of the Invention

[0010] An object of the present invention is to provide a device and a method for controlling of tool vibrations, said device and said method having no or at least a negligible negative effect on the dimensions of the tool.

[0011] Another object of the present invention is to provide a device and a method for controlling of tool vibrations, said device and said method having no or at least a negligible negative effect on the mechanical properties of the tool.

[0012] A further object of the invention is to provide a device and a method for controlling of tool vibrations, said device and said method producing a directed and direct control of the tool vibrations.

[0013] One more object of the invention is to provide a device and a method for controlling of tool vibrations, said device and said method enabling control of tool vibrations in an optional direction.

[0014] The objects with regard to a device are achieved by a device for vibration control in a machine for cutting, said machine comprising a cutting tool supported by a tool holder, the device comprising a control unit and converting means which are connectible to the control unit and comprise a vibration sensor and an actuator, and the actuator comprising an active element which converts an A.C. voltage supplied by the control unit across the actuator into dimensional changes. The device is characterised in that said active element is adapted to be embedded in the body of the tool holder, and that said active element is adapted to be embedded in such manner that said dimensional changes impart turning moments to the body of the tool holder, according to claim 1.

[0015] The objects with regard to a method are achieved by a method for vibration control in cutting according to claim 7, comprising the steps of detecting the vibrations of a tool holder during cutting, and generating control vibrations in the tool holder, by means of at least one active element which is electrically controllable to dimensional changes. The method is characterised by the steps of embedding said active element in the body of the tool holder and, for generating the control vibrations, imparting turning moments to the body of the tool holder by generating at least one control voltage and applying the control voltage across said active element, and by varying the control voltage according to the detected vibrations.

[0016] The idea of embedding according to the invention at least one active element in the tool holder, as per claim 9, implies a minimal modification of the tool holder and at the same time uses the rapidity and the capability of changing dimensions of the active element in an optimal manner. The embedding makes it possible to transfer more efficiently the dimensional change direct to the body of the tool holder and with maximum efficiency. The prior-art technique according to JP-63,180,401 where the actuator element is arranged freely except for the end walls gives space for outwards bending of the actuator element, whereby power is lost. The embedding is also advantageous by the device being usable in practice since it is protected against cutting fluids and chips. The known devices are possibly usable for laboratories, but not in the industry.

[0017] The device is adapted to impart a turning moment to the tool holder through the arrangement of the active element/elements. The corresponding actuator element in JP-63,180,401 is deliberately arranged so that the dimensional change occurs along the longitudinal axis of the tool holder, which does not result in a turning moment. This depends on the above-mentioned lack of knowledge of what primarily causes the vibration problems. Thus one has not realised that the most important excitation forces have any other direction but parallel with said longitudinal axis. Even with this knowledge, the construction according to JP-63,180,401, however, is not easily adjustable to any other kind of mounting than the one shown.

[0018] The active element according to the invention can be made small. This makes it easy to build the active element into the tool holder when manufacturing the same without any detrimental effect on the mechanical properties of the tool holder. Besides it will be possible later to mount the element in existing tool holders.

[0019] Moreover, the mounting will be flexible since the active element may be mounted with an optional orientation. Consequently it will be possible to achieve maximum controllability for vibrations of practically any direction whatever.

Brief Description of the Drawings

[0020] The invention will now be described in more detail with reference to the accompanying drawings, in which

Fig. 1 exemplifies in a perspective view the application of forces on a cutting tool;

Fig. 2 is a schematic cross-sectional view of an embodiment of the invention applied to a tool for turning;

Fig. 3 is a block diagram of controlling according to the embodiment in Fig. 2; and

Fig. 4 illustrates a different embodiment of the invention applied to a tool for milling.

Detailed Description of Embodiments

[0021] A basic object of the invention is to counteract the arising of vibrations causing noise, wear and uneven surfaces in connection with cutting of a workpiece. The casual relation for the arising of vibrations in cutting has been described above. A correctly performed vibration control according to the invention obviates the problems and results in an excellent surface finish.

[0022] Fig. 1 shows an example of forces to which a tool 1, in this case a turning insert, is exposed owing to the working of a workpiece 2. The tool 1 is supported by a tool holder 3, with which the tool 1 is rigidly connected. The workpiece 2 rotates in the direction of arrow A. The tool holder 3 moves in a direction of feed indicated by arrow B. The rotation of the workpiece 2 and the motion of the tool holder 3 together generate a resultant force as illustrated by arrow f. The resultant force f can be divided into components f_f, f_p and f_v. As appears from Fig. 1, the dominating component is f_v which designates the force required to remove material from the workpiece 2.

[0023] Fig. 2 exemplifies an embodiment of the inventive device and how this embodiment is used in turning. Fig. 2 is a schematic longitudinal cross-section of a tool

in the form of a turning insert 21, and a tool holder in the form of a turning insert holder 23, which correspond to the tool 1 and the tool holder 3, respectively, in Fig. 1. A rotating workpiece is shown in cross-section at 22. The inventive device is in this example arranged to reduce/counteract the vibrations caused by the force component f_v and indicated by arrow C. The device comprises converting means, which consist of plate-shaped sensors 24, 25 and plate-shaped actuators 26, 27. The actuators 26, 27 comprise active elements, here one element each, which in this embodiment consist of piezoceramic elements which change dimension when an electric voltage is applied across them. The dimensional change is related to the voltage. A piezoceramic element can in turn be designed as a unit or advantageously be made up as a so-called stack and/or of several partial elements. Thus, the element can be a solid body or a plurality of individual, but composed and interacting bodies. The sensors 24, 25 are piezoelectric crystals which generate an electric voltage when subjected to forces. The device further comprises a control unit 28 which is electrically connected to the sensors 24, 25 and the actuators 26, 27 via a conduit 29 containing a plurality of conductors. For the sake of clarity, only those conductors 30-33 are shown in the tool holder 23 which are connected to the actuators 26, 27, but of course conductors are also arranged for the sensors 24, 25.

[0024] The active elements, i.e. the piezoceramic elements, 26, 27 are embedded in the tool holder 23. In this case, and as a preferred embodiment, the embedding is made by casting. The casting is carried out by forming for each active element 26, 27 a recess in the body of the tool holder 23, whereupon the active element 26, 27 is arranged therein and covered by casting. The active element 26, 27 is glued preferably to the bottom surface of the recess. The sensors 24, 25 are fixed by casting in the same way as the active elements. The conductors 30-33 are also cast into the tool holder 23.

[0025] The converting means 24-27 are oppositely arranged in pairs and in parallel, in the form of one pair of sensors 24, 25 and one pair of actuators 26, 27. An upper sensor 24 of the sensors 24, 25 is arranged close to the upper side 23a of the tool holder 23, and a lower sensor 25 of the sensors 24, 25 is arranged close to the underside 23b of the tool holder 23. The actuators 26, 27 are arranged correspondingly, i.e. with an upper and a lower actuator 26, 27 arranged close to the upper side 23a and the underside 23b, respectively, of the tool holder 23.

[0026] The device operates as follows. When during turning the tool 21 and the tool holder 23 vibrate up and down according to arrow C, the sensors 24, 25 are subjected to alternating pulling and pressing forces. Each sensor 24, 25 then generates a voltage which varies concurrently with the variations in forces. The sensor voltages are detected and analysed by the control unit 28. The control unit 28 generates two control voltages, in the form of A.C. voltages, which are supplied to an actuator 26, 27 each and are applied across the piezoceramic elements 26, 27. The piezoceramic elements 26, 27 are elongate in the longitudinal direction of the tool holder 23, and the conductors 30-33 are connected in pairs to a piezoceramic element 26, 27 each in their respective front ends 26a, 27a and rear ends 26b, 27b. When voltage is applied to the actuators 26, 27 by means of the control voltages, the piezoceramic elements 26, 27 are thus extended to a greater or smaller degree depending on the magnitude of the voltages. In other words, each piezoceramic element 26, 27 obtains a dimensional change in its longitudinal direction, which in the present example is also the longitudinal direction of the tool holder 23. The piezoceramic elements 26, 27 preferably have power-transmitting surfaces, in this case their end surfaces at the ends 26a, 26b, 27a, 27b which abut directly against surfaces in the body of the tool holder 23. Moreover, the piezoceramic elements 26, 27 are spaced from the centre axis I-I of the tool holder 23. The expression "spaced from the centre axis" means in general terms that the centre axes of the piezoceramic elements 26, 27 do not coincide with the centre axis of the tool holder 23. If the centre axes should coincide, no turning moment would be obtained, but merely a pure longitudinal change of the tool holder 23. In the preferred embodiment, the piezoceramic elements 26, 27 are arranged close to the surface for the moment arms to be as long as possible. In the present example, the dominating vibration is vertical, which means that the forces induced by means of the piezoceramic elements 26, 27 in the first place strive to bend the end of the tool holder 23 upwards and downwards.

[0027] The turning moments thus act round an axis which is perpendicular to the centre axis I-I and are controlled so as to operate in opposition to the turning moments induced by the workpiece 22 during working owing to its rotation. This reduces the vibrations. Thus the control unit 28 generates such control voltages that the forces induced by the actuators 26, 27 are in opposition to the forces detected by the sensors 24, 25.

[0028] The control unit 28 is selectable among many different types, such as analog, fed-back control unit, conventional PID regulator, adaptive regulator or some other control unit suitable in a current application. Preferably the control unit strives to control the vibrations towards an optimal state. The control can imply, for instance, minimising of the vibrations in one or all directions, in which case the optimal state can be completely extinguished vibrations. A large number of known control algorithms are available. It is desirable to find the most efficient one for a certain application. Regarding the above-described embodiment in connection with turning, the analysis of the sensor signals, i.e. the voltages generated by the sensors, and the generation of the control signals, i.e. the control voltages, to the piezoceramic elements 26, 27 occur as follows.

[0029] A preferred embodiment of the control system which the control unit 28, the sensors 24, 25 and the

piezoceramic elements 26, 27 constitute, is fed back and based on a so-called "Filtered-X LMS-algorithm". It is true that this algorithm is per se known to those skilled in the art. Fig. 3 illustrates an equivalent block diagram of the fed-back control system in a digital description.

[0030] Block 301, which is also designated C, represents the dynamic system controlled, which contains the actuators 26, 27 and the sensors 24, 25. The other blocks represent an implementation of said algorithm. Block 305 represents an FIR filter with adjustable coefficients, block 307 represents an adaptive coefficient adjusting means, and block 309 represents a model (C*) of the dynamic system 301.

[0031] Seen from a functional, mathematic perspective, the dynamic system constitutes a forward filter, whose output signal, i.e. the response of the dynamic system, is $y_c(n)$. The coefficient adjusting means 307 strives to optimise the coefficients of the FIR filter so that an error signal e(n) is minimised. The error signal e(n) $=d(n)- y_c(n)$ where d(n) is a desirable output signal. The determination of the error signal is carried out by means of a summer 311. To ensure that the coefficient adjusting means converges each time independently of its initial state, it is supplied with a reference signal r(n) from the model 309 of the forward filter.

[0032] In mathematical terms it is possible to describe the effect of the invention by saying that it changes the transmission of the tool holder and, more specifically, changes the properties of one or more forward channels, each forward channel being associated with an excitation direction. This way of looking at the matter is equivalent to the effect of the invention being that control vibrations are generated, which influence the vibrations of the tool holder. It should thus be pointed out that in many cases the forward channel cannot be considered time-invariant, i.e. a traditional linear systems theory is in many cases not applicable. The system is usually non-linear.

[0033] The invention is applicable not only to turning but functions also for other types of cutting, such as milling or drilling, in which also the above described control algorithm is applicable.

[0034] In milling, the workpiece does not rotate, but instead the tool itself and its tool holder. Fig. 4 shows a milling tool holder 41, whose direction of rotation is indicated by an arrow. The milling tool holder 41 has embedded sensors and active elements, of which two active elements 45, 47 are schematically shown. The most important vibrations that arise in milling are caused by torsion of the milling tool holder 41 owing to the engagement of the cutting edges 43 in the material of the workpiece. The milling tool holder 41 is also subjected to a certain degree of bending. The resultant forces are mainly helically directed round the axis of rotation of the milling tool holder 41. A preferred arrangement of the active elements 45, 47b therefore is in a band round the milling tool holder 41 so that the active elements have an essential extent and simultaneously a direction of action helically round the axis of rotation of the tool holder 41. Thus, the resulting turning moments act essentially in the same directions as said torsion. A conceivable variant of or combination with the helical arrangement, however, is also to arrange the active elements parallel with the axis of rotation.

[0035] In drilling, like in milling, the tool and the tool holder rotate. Drills have a tool in the form of drilling teeth supported by a tool holder. The teeth are usually welded to the holder. However, also so-called high-speed-steel drills are available, in which the tool holder and the tool are integrally made. Also in that case, however, the drill comprises in terms of definition a tool in the form of the actual teeth at the end of the drill and a tool holder in the form of the remaining part of the drill. In drilling, the circumstances resemble those prevailing in milling. A clear distinction, however, is to be found in the direction of feed, which in drilling is parallel with the axis of rotation of the tool holder whereas it is perpendicular to the axis of rotation of the tool in milling. A further distinction is that the entire tool abuts against the workpiece in drilling whereas in milling the abutment is only partial. Therefore, in drilling the vibrations are almost exclusively related to torsion. Active elements and sensors are arranged in about the same way as in milling, but at a greater angle to the axis of rotation.

[0036] Also vibrations in planing tools and other cutting tools can be controlled according to the invention.

[0037] An alternative arrangement of sensors is, in connection with turning, between the actual insert and the tool holder, i.e. below the insert. In that case, a pressure-sensitive sensor is used.

[0038] Besides, the sensors can be of different types. In addition to those mentioned above, use can be made of e.g. accelerometers and strain gauges. The latter, however, are less suitable than the piezoelectric sensors from the environmental point of view.

[0039] Also the active elements can be of different types within the scope of the invention. In the future, even thinner elements than those used today will probably be conceivable, for instance in the form of piezofilm (PZT). The currently preferred type, however, is piezoceramic elements.

[0040] The above-described arrangements of the sensors and actuators are examples of arrangements and many variants are possible, such as a combination of those shown or other numbers of actuators. For instance, in turning, it is possible to arrange two pairs of actuators in each direction or a plurality of actuators adjacent to those shown. In its simplest embodiment, the inventive device comprises only one actuator which comprises one active element. This, however, results in a more non-linear control system, which causes unnecessary technical difficulties in controlling. Therefore it is an advantage to balance the system by arranging, like in the embodiment shown in Fig. 2, the active elements in pairs opposite each other, i.e. opposite each other on each side of the centre axis of the tool holder. A still

greater linearity is achieved if each actuator is besides formed of two active elements which are joined, for example by gluing, with each other, large face to large face, into a double element. The double element will certainly be twice as thick as a single element, but gives a more dynamic effect, which sometimes is preferable.

[0041] The active elements are in respect of form not bound to be rectangularly parallelepipedal and plate-shaped as the elements shown, but the form may vary according to the application. The plate shape, however, is advantageous since it contributes to minimising the volume of the element. Moreover, an elongate form is a good property which also contributes to imparting to the element a small volume. It is preferred for the dimensional changes to occur in the longitudinal direction of the element.

[0042] The arrangement of the active elements in the tool holder may vary and certainly also affects the form. In addition to the above-described, preferred mounting where the elements certainly are glued to the base of the recess but two opposite power-transmitting surfaces essentially generate the turning moments, other alternatives are possible. One alternative implies that the dimensional change is fully transferred via the glue joint, which in principle is possible with today's strongest glues. Also other variants are contained within the scope of the invention.

[0043] The active element is covered by casting, using a suitable material. As an example, plastic materials can be mentioned. Preferably, however, a cover of metal is arranged on top and on the same level as the remaining tool holder surface.

Claims

1. A device for vibration control in a machine for cutting, said machine comprising a cutting tool (21, 43) supported by a tool holder (3, 23, 41), the device comprising a control unit (28) and converting means which are connectible to the control unit and comprise a vibration sensor (24, 25) and an actuator (26, 27, 45, 47), and the actuator comprising an active element (26, 27, 45, 47) which converts an A. C. voltage supplied by the control unit to the actuator into dimensional changes, **characterised in that** said active element is adapted to be embedded in the body of the tool holder, that said active element is adapted to be embedded for imparting turning moments to the body of the tool holder through said dimensional changes, and that the control unit is adapted, by means of said active element, to control vibrations which are a result of a dynamic excitation of the tool holder in a chip forming process.

2. A device as claimed in claim 1, **characterised in that** said active element (26, 27, 45, 47) is adapted to be embedded with its centre axis spaced from the centre axis of the tool holder (3, 23, 41).

3. A device as claimed in claim 1 or 2, **characterised in that** said active element (26, 27, 45, 47) is adapted to be embedded close to the surface of the tool holder (3, 23, 41).

4. A device as claimed in any one of the preceding claims, **characterised in that** said active element (26, 27, 45, 47) is plate-shaped.

5. A device as claimed in any one of the preceding claims, **characterised in that** said actuator (26, 27, 45, 47) comprises a double element which consists of two active elements which are connected with each other via a large face each.

6. A device as claimed in any one of the preceding claims, **characterised in that** said active element (26, 27, 45, 47) is a piezoceramic element.

7. A method for vibration control in cutting, comprising the steps of detecting the vibrations of a tool holder during cutting, and generating control vibrations in the tool holder, by means of at least one active element which is electrically controllable to dimensional changes, **characterised by** the steps of embedding said active element in the body of the tool holder, imparting, for generating the control vibrations, turning moments to the body of the tool holder by generating at least one control voltage and applying the control voltage across said active element, and by varying the control voltage according to the detected vibrations, and thereby controlling vibrations which are a result of a dynamic excitation of the tool holder in a chip forming process.

8. A method as claimed in claim 7, **characterised by** detecting the vibrations of the tool holder piezoelectrically.

9. A tool holder which is adapted to support a tool for cutting, the tool holder (3, 23, 41) comprising an actuator (26, 27, 45, 47), said actuator comprising an active element (26, 27, 45, 47) which is electrically controllable to dimensional changes, **characterised in that** the active element (26, 27, 45, 47) is embedded in the body of the tool holder, wherein it is adapted to impart, through said dimensional changes, turning moments to the body of the tool holder, and that the active element is usable for controlling vibrations which are a result of a dynamic excitation of the tool holder in a chip forming process.

10. A tool holder as claimed in claim 9, **characterised in that** said active element (26, 27, 45, 47) is embedded with its centre axis spaced from the centre

axis of the tool holder (3, 23, 41).

11. A tool holder as claimed in claim 9 or 10, **characterised in that** said active element (26, 27, 45, 47) is embedded close to the surface of the tool holder (3, 23, 41).

12. A tool holder as claimed in claim 9, 10 or 11, **characterised in that** at least one pair of active elements is arranged in such manner that the active elements included in the pair are oppositely arranged on each side of the centre axis of the tool holder (3, 23, 41).

13. A tool holder as claimed in any one of claims 9-12, **characterised in that** said active element (26, 27, 45, 47) is arranged in a recess in the tool holder (3, 23, 41) and is connected with the tool holder via a glue joint which transfers at least part of said dimensional change to the tool holder, and that the recess is sealed.

14. A tool holder as claimed in any one of claims 9-13, **characterised in that** said active element (26, 27, 45, 47) is arranged in a recess in the tool holder (3, 23, 41) and has two opposite power transmitting surfaces, said power transmitting surfaces being engaged with surfaces of the body of the tool holder and said dimensional changes changing the distance between the power transmitting surfaces, and that the recess is sealed.

15. A tool holder as claimed in any one of claims 9-14, **characterised in that** it consists of a teeth holder (3, 23) for a turning lathe.

16. A tool holder as claimed in any one of claims 9-14, **characterised in that** it consists of a teeth holder (41) for a milling machine, and that the teeth holder comprises active elements (45, 47) which are helically arranged round the centre axis of the teeth holder.

17. A tool holder as claimed in any one of claims 9-14, **characterised in that** it consists of a teeth holder for a drilling machine, and that the teeth holder comprises active elements which are helically arranged round the centre axis of the teeth holder.

18. A tool holder as claimed in any one of claims 9-17, **characterised in that** it comprises an embedded, piezoelectric sensor element (24, 25).

19. A tool holder as claimed in any one of claims 9-18, **characterised in that** said embedded elements are cast into the body of the tool holder.

20. A tool holder as claimed in any one of claims 9-19, **characterised in that** said active element is a piezoceramic element.

21. Use of a device as claimed in any one of claims 1-6 in a machine, the machine being one of a machine for turning, a machine for milling or a machine for drilling.

Patentansprüche

1. Vorrichtung zur Schwingungskontrolle in einer Maschine zum Schneiden, wobei die Maschine ein von einem Werkzeughalter (3, 23, 41) getragenes Schneidwerkzeug (21, 43) umfasst, die Vorrichtung eine Steuereinheit (28) und eine Umwandlungseinrichtung umfasst, die an die Steuereinheit anschließbar ist und einen Schwingungsfühler (24, 25) und einen Aktuator (26, 27, 45, 47) umfasst, wobei der Aktuator ein aktives Element (26, 27, 45, 47) umfasst, das eine von der Steuereinheit an den Aktuator gelieferte Wechselspannung in Maßänderungen umwandelt,
dadurch gekennzeichnet,
dass das aktive Element zum Einbetten in den Körper des Werkzeughalters abgestimmt ist, das aktive Element zum Einbetten abgestimmt ist, um dem Körper des Werkzeughalters Drehmomente durch die Maßänderungen zu übermitteln, und die Steuereinheit mittels des aktiven Elements abgestimmt wird, um Schwingungen zu kontrollieren, die das Ergebnis einer dynamischen Anregung des Werkzeughalters in einem spanenden Formungsverfahren sind.

2. Vorrichtung nach Anspruch 1,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) abgestimmt ist, um mit der Mittelachse von der Mittelachse des Werkzeughalters (3, 23, 41) beabstandet eingebettet zu werden.

3. Vorrichtung nach Anspruch 1 oder 2,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) abgestimmt ist, um nahe der Oberfläche des Werkzeughalters (3, 23, 41) eingebettet zu werden.

4. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) plattenförmig ist.

5. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
dass der Aktuator (26, 27, 45, 47) ein Doppelele-

ment umfasst, das aus zwei aktiven Elementen besteht, die jeweils durch eine große Fläche miteinander verbunden sind.

6. Vorrichtung nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) ein piezokeramisches Element ist.

7. Verfahren zur Schwingungskontrolle beim Schneiden, welches die folgenden Schritte umfasst:

Erfassen der Schwingungen eines Werkzeugshalters während des Schneidens und
Erzeugen von Kontrollschwingungen im Werkzeughalter mittels wenigstens eines aktiven Elements, welches elektrisch auf Maßänderungen kontrollierbar ist, **gekennzeichnet durch** die Schritte eines Einbettens des aktiven Elements in den Körper des Werkzeughalters, eines Übermittelns von Drehmomenten auf den Körper des Werkzeughalters zum Erzeugen der Kontrollschwingungen, indem wenigstens eine Steuerspannung erzeugt und die Steuerspannung auf das aktive Element angelegt wird, und indem die Steuerspannung entsprechend der erfassten Schwingungen variiert wird und **dadurch** die Schwingungen kontrolliert werden, die das Ergebnis einer dynamischen Anregung des Werkzeughalters in einem spanenden Formungsverfahren sind.

8. Verfahren nach Anspruch 7,
dadurch gekennzeichnet,
dass die Schwingungen des Werkzeughalters piezoelektrisch erfasst werden.

9. Werkzeughalter, der zum Tragen eines Schneidwerkzeugs abgestimmt ist, wobei der Werkzeughalter (3, 23, 41) einen Aktuator (26, 27, 45, 47) umfasst, welcher ein aktives Element (26, 27, 45, 47) umfasst, das elektrisch auf Maßänderungen kontrollierbar ist,
gekennzeichnet dadurch,
dass das aktive Element (26, 27, 45, 47) im Körper des Werkzeughalters eingebettet ist, in dem es abgestimmt wird, um dem Körper des Werkzeughalters durch die Maßänderungen Drehmomente zu übermitteln, und das aktive Element zum Kontrollieren von Schwingungen verwendet werden kann, die das Ergebnis einer dynamischen Anregung des Werkzeughalters in einem spanenden Formungsverfahren sind.

10. Werkzeughalter nach Anspruch 9,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) mit der Mittelachse von der Mittelachse des Werkzeughalters (3, 23, 41) beanstandet eingebettet ist.

11. Werkzeughalter nach Anspruch 9 oder 10,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) nahe der Oberfläche des Werkzeughalters (3, 23, 41) eingebettet ist.

12. Werkzeughalter nach Anspruch 9, 10 oder 11,
dadurch gekennzeichnet,
dass wenigstens ein Paar aktiver Element so angeordnet ist, dass die in dem Paar enthaltenen aktiven Elemente auf jedem Ende der Mittelachse des Werkzeughalters (3, 23, 41) jeweils einander gegenüber angeordnet sind.

13. Werkzeughalter nach einem der Ansprüche 9 bis 12,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) in einer Vertiefung im Werkzeughalter (3, 23, 41) angeordnet und durch eine Klebverbindung mit dem Werkzeughalter verbunden ist, die dem Werkzeughalter wenigstens einen Teil der Maßänderung übermittelt, und die Vertiefung abgedichtet ist.

14. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 13,
dadurch gekennzeichnet,
dass das aktive Element (26, 27, 45, 47) in einer Vertiefung in dem Werkzeughalter (3, 23, 41) angeordnet ist und zwei gegenüberliegende energieübertragende Oberflächen aufweist, wobei die energieübertragenden Oberflächen mit Oberflächen des Körpers des Werkzeughalters in Eingriff stehen und die Maßänderungen den Abstand zwischen den energieübertragenden Oberflächen verändern, und die Vertiefung abgedichtet ist.

15. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 14,
dadurch gekennzeichnet,
dass dieser aus einem Zahnhalter (3, 23) für eine Drehbank besteht.

16. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 14,
dadurch gekennzeichnet,
dass dieser aus einem Zahnhalter (41) für eine Fräsmaschine besteht, und der Zahnhalter aktive Elemente (45, 47) umfasst, die schraubenförmig um die Mittelachse des Zahnhalters angeordnet sind.

17. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 14,
dadurch gekennzeichnet,

dass dieser aus einem Zahnhalter (3, 23) für eine Bohrmaschine besteht, und der Zahnhalter aktive Elemente umfasst, die schraubenförmig um die Mittelachse des Zahnhalters angeordnet sind.

18. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 17,
dadurch gekennzeichnet,
dass dieser ein eingebettetes, piezoelektrisches Fühlerelement (24, 25) umfasst.

19. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 18,
dadurch gekennzeichnet,
dass die eingebetteten Elemente in den Körper des Werkzeughalters eingegossen sind.

20. Werkzeughalter nach einem der vorhergehenden Ansprüche 9 bis 19,
dadurch gekennzeichnet,
dass das aktive Element ein piezokeramisches Element ist.

21. Verwendung einer Vorrichtung nach einem der vorhergehenden Ansprüche 1 bis 6 in einer Maschine, wobei diese Maschine eine Maschine zum Drehen, eine Maschine zum Fräsen oder eine Maschine zum Bohren ist.

Revendications

1. Dispositif de commande de vibration dans une machine de coupe, la dite machine comprenant un outil de coupe (21, 43) supporté par un porte-outil (3, 23, 41), le dispositif comprenant une unité de commande (28) et des moyens de conversion qui peuvent être connectés à l'unité de commande et qui comprennent un détecteur de vibration (24, 25) et un actionneur (26, 27, 45, 47), et l'actionneur comprenant un élément actif (26, 27, 45, 47) qui convertit une tension alternative fournie par l'unité de commande à l'actionneur en changements dimensionnels, **caractérisé en ce que** le dit élément actif est prévu pour être noyé dans le corps du porte-outil, **en ce que** le dit élément actif est prévu pour être noyé de façon à communiquer des moments de rotation au corps du porte-outil par l'intermédiaire des dits changements dimensionnels, et **en ce que** l'unité de commande est prévue, par l'intermédiaire du dit élément actif, pour commander des vibrations qui sont un résultat d'une excitation dynamique du porte-outil dans une opération de formation de copeaux.

2. Dispositif selon la revendication 1, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est prévu pour être noyé de sorte que son axe central est espacé de l'axe central du porte-outil (3, 23, 41).

3. Dispositif selon la revendication 1 ou 2, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est prévu pour être noyé près de la surface du porte-outil (3, 23, 41).

4. Dispositif selon une quelconque des revendications précédentes, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est en forme de plaque.

5. Dispositif selon une quelconque des revendications précédentes, **caractérisé en ce que** le dit actionneur (26, 27, 45, 47) comprend un double élément qui consiste en deux éléments actifs qui sont mutuellement connectés via une grande face de chacun.

6. Dispositif selon une quelconque des revendications précédentes, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est un élément piézocéramique.

7. Procédé de commande de vibration dans une machine de coupe, comprenant les étapes de détection des vibrations d'un porte-outil pendant la coupe, et de génération de vibrations de commande dans le porte-outil, au moyen d'au moins un élément actif qui peut être commandé électriquement pour subir des changements dimensionnels, **caractérisé par** les étapes d'encastrement du dit élément actif dans le corps du porte-outil ; de communication, pour engendrer les vibrations de commande, de moments de rotation au corps du porte-outil par génération d'au moins une tension de commande et application de la tension de commande aux bornes du dit élément actif ; et de variation de la tension de commande en fonction des vibrations détectées, afin de commander des vibrations qui sont un résultat d'une excitation dynamique du porte-outil dans une opération de formation de copeaux.

8. Procédé selon la revendication 7, **caractérisé par** la détection des vibrations du porte-outil de façon piézoélectrique.

9. Porte-outil qui est prévu pour supporter un outil de coupe, le porte-outil (3, 23, 41) comprenant un actionneur (26, 27, 45, 47), le dit actionneur comprenant un élément actif (26, 27, 45, 47) qui peut être électriquement commandé de façon à subir des changements dimensionnels, **caractérisé en ce que** l'élément actif (26, 27, 45, 47) est noyé dans le corps du porte-outil de sorte qu'il peut appliquer, par l'intermédiaire des dits changements dimensionnels, des moments de rotation au corps du porte-outil, et **en ce que** l'élément actif est utilisable pour commander des vibrations qui sont un résultat

d'une excitation dynamique du porte-outil dans une opération de formation de copeaux.

10. Porte-outil selon la revendication 9, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est noyé de sorte que son axe central est espacé de l'axe central du porte-outil (3, 23, 41).

11. Porte-outil selon la revendication 9 ou 10, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est noyé près de la surface du porte-outil (3, 23, 41).

12. Porte-outil selon la revendication 9, 10 ou 11, **caractérisé en ce qu'**au moins une paire d'éléments actifs est agencée d'une manière telle que les éléments actifs inclus dans la paire sont agencés en opposition de part et d'autre de l'axe central du porte-outil (3, 23, 41).

13. Porte-outil selon une quelconque des revendications 9 à 12, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est agencé dans un évidement du porte-outil (3, 23, 41) et il est relié au porte-outil par une jonction collée qui transfère au moins une partie du dit changement dimensionnel au porte-outil, et **en ce que** l'évidement est scellé.

14. Porte-outil selon une quelconque des revendications 9 à 13, **caractérisé en ce que** le dit élément actif (26, 27, 45, 47) est agencé dans un évidement du porte-outil (3, 23, 41) et présente deux surfaces opposées de transmission de puissance, les dites surfaces de transmission de puissance étant en contact avec des surfaces du corps du porte-outil et les dits changements dimensionnels modifiant la distance entre les surfaces de transmission de puissance, et **en ce que** l'évidement est scellé.

15. Porte-outil selon une quelconque des revendications 9 à 14, **caractérisé en ce qu'**il consiste en un porte-lames (3, 23) pour un tour rotatif.

16. Porte-outil selon une quelconque des revendications 9 à 14, **caractérisé en ce qu'**il consiste en un porte-lames (41) pour une fraiseuse, et **en ce que** le porte-lames comprend des éléments actifs (45, 47) qui sont agencés hélicoïdalement autour de l'axe central du porte-lames.

17. Porte-outil selon une quelconque des revendications 9 à 14, **caractérisé en ce qu'**il consiste en un porte-lames pour une perceuse, et **en ce que** le porte-lames comprend des éléments actifs qui sont agencés hélicoïdalement autour de l'axe central du porte-lames.

18. Porte-outil selon une quelconque des revendications 9 à 17, **caractérisé en ce qu'**il comprend un élément de détection piézoélectrique noyé (24, 25).

19. Porte-outil selon une quelconque des revendications 9 à 18, **caractérisé en ce que** les dits éléments noyés sont placés au moulage à l'intérieur du corps du porte-outil.

20. Porte-outil selon une quelconque des revendications 9 à 19, **caractérisé en ce que** le dit élément actif est un élément piézocéramique.

21. Utilisation d'un dispositif selon une quelconque des revendications 1 à 6, dans une machine, la machine étant l'une d'une machine de tournage, d'une machine de fraisage ou d'une machine de perçage.

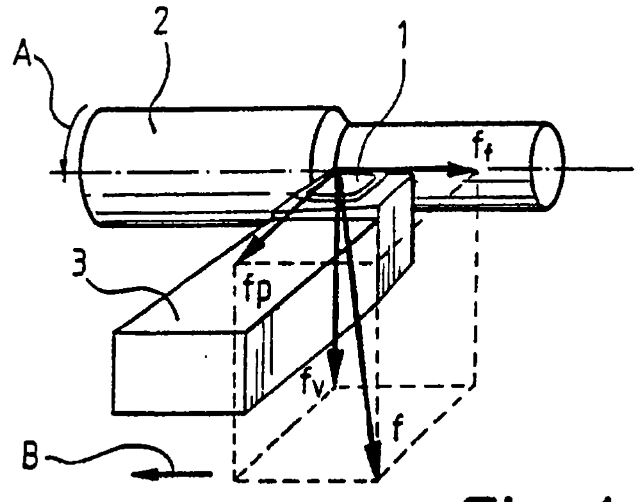
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Fig. 1

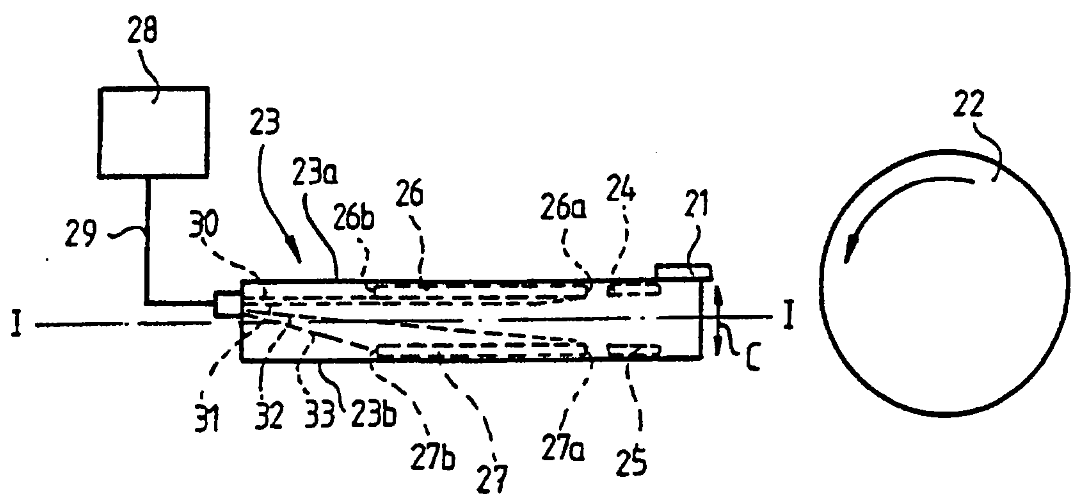
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Fig. 2

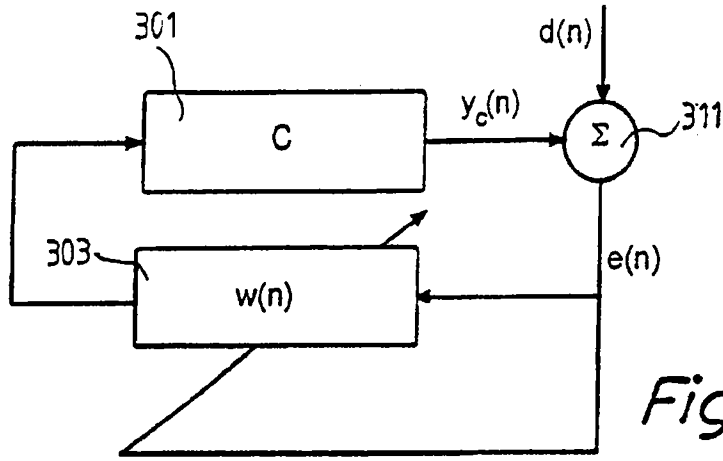

Fig. 3a

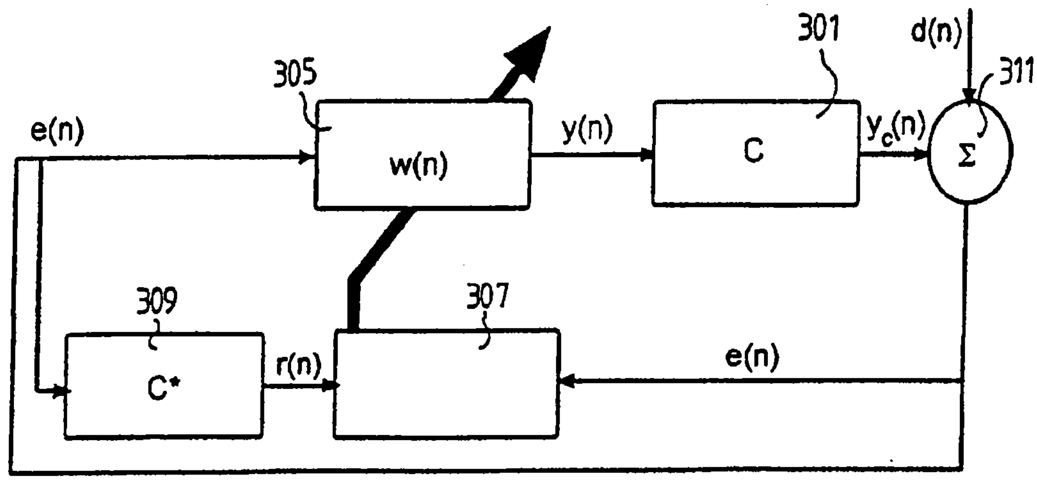

Fig. 3b

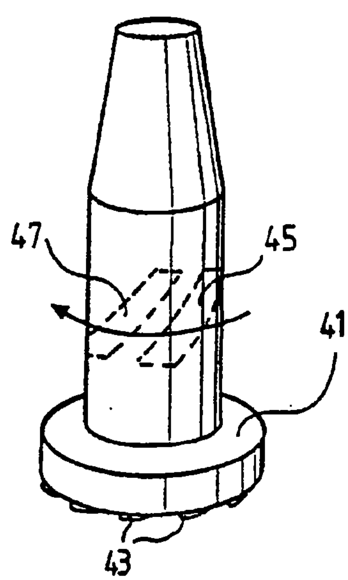

Fig. 4